STRATEGY RESEARCH PROJECT

TELEMEDICINE: AN OVERVIEW WITH IMPLICATIONS FOR MILITARY USE

BY

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ABSTRACT

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Telemedicine. What is it? How does it apply to the military? Does it work? These and many more questions are still being asked even though telemedicine has been utilized by medical professionals around the world for at least the past decade. These questions take on even more importance if the Department of Defense investment in telemedicine for the years of 1993-1998, of 327 million dollars is considered. With over 192 projects identified that received these funds, it is important that every senior military leader, not just medical officers, have a basic understanding of telemedicine and its impact on daily operations. This paper will look at a history of telemedicine, its current status in the civilian community, and finally its application in military medicine.

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TELEMEDICINE: AN OVERVIEW WITH IMPLICATIONS FOR MILITARY USE

The influx of recent advanced communications technologies, coupled with changing incentives in the health care marketplace, has resulted in a resurgence of interest in the potential of telemedicine. This technology is expected to affect health care providers, payers, and consumers in both the public and private sectors. Telemedicine is also expected to impact how medical care is delivered, who delivers it, and who pays for it. Although many players throughout the federal government and the private sector are involved in telemedicine, the Department of Defense (DOD) is considered a leader in research related to telemedicine efforts. DOD has devised ways to use this new technology to deliver health care on the battlefield or during peacetime operations.

DEFINITION

The American Telemedicine Association uses the following broad definition of telemedicine: "Telemedicine is the use of medical information exchanged from one site to another via electronic communications for the health and education of the patient or healthcare provider and for the purpose of improving patient care."[1] Another view on what telemedicine is can be seen in a briefing given to Congress in 1999 on telehealth,

> "Telemedicine utilizes information and telecommunications technology to transfer medical information for diagnosis, therapy and education. The information may include medical images, live two-way audio and video, patient medical records, output data from medical devices and sound files. The telemedical interaction may involve two-way live audio and video visits between patients and medical professionals, sending patient monitoring data from the home to a clinic or transmitting a patient medical file from a primary care provider to a specialist."[2]

By moving information rather than patients and physicians, telemedicine promises to enhance healthcare while dismantling the barriers of where and when medical services are provided. Telemedicine can be defined as the electronic transmission of medical information and services (voice, data, and video) from one site to another using telecommunication technology. This is a very broad definition. It includes a simple phone call, complex interactive video consultations, and even remote robotic surgery. In isolated regions, telemedicine applications have potential significance for improving access to specialized health services for both patients and providers. Telemedicine is used for education record maintenance, patient monitoring, diagnostics, consultation, and treatment. Both the public and private sectors have created telemedicine networks, and the application of modern telecommunications technologies is leading the growth of this new dimension in healthcare.

While the literal translation of telemedicine is "medicine at a distance," the industry and the services it represents have evolved into much more that that. Telemedicine involves the use of standard telephone lines, the Internet, or high speed digital lines to transmit electronic medical data between hospitals, physicians/ offices and medical center. Wireless communications has become commonplace, and is also being exploited in telemedicine. The process may be as simple as an interactive video session between a primary-care physician with a question and a specialist with the answer. Or it might involve large-scale networks that transmit X-ray images, CT (computerized tomography) scans, or MRI (magnetic resonance imaging) studies for interpretation and diagnosis in real time.

Telemedicine technologies assist off-site specialists in providing backup support for primary physicians in rural health centers and small hospitals. They are also used to extend care for patients at home—for instance, to monitor medication compliance, evaluate vital signs. Or enable interactive assessment of glucose levels. Thus, telemedicine can benefit urban residents as well.

Telemedicine more than any other innovation in health care exemplifies the challenges facing health care in the Information Age. As a medical discipline, telemedicine actually has a 40-year history, but it only began to grow in the early 1990s, thanks to innovations in telecommunications and technology and their increased affordability. For example, interactive therapy as been used for group mental health therapy in Nebraska since 1959, but the early technology proved too costly for its use to increase.[3] But it the 1990s, telemedicine has snowballed because of developments in digital imaging and transmission. In fact, almost all the substantial discussion about telemedicine takes place in the 1990s literature. A few years ago, the cost of setting up a telemedicine operation was about $300,000, but today that cost has been reduced to less than $50,000, according to the American Telemedicine Association, a Washington, DC-based trade organization that has promoted telemedicine throughout the world since 1993. "Telemedicine has come a long way in a short time because costs are a mere fraction of what they once were," says the group's executive director, Jon Linkous. "Just look at what it costs to buy a computer as compared to five years ago."[4]

Some of the major medical fields in which telemedicine is already being used includes radiology, ophthalmology, cardiology, pathology, and dermatology. For example, teleradiology—the transmission of medical images (through X-ray or magnetic resonance imaging, for example) to a radiologist for interpretation—is the single most common use of telemedicine in the United States.[5] Also, through telemedicine, almost all interactions between dermatologists and their patients could be accomplished long-distance. In such a scenario, a rural health provider would use a dermascope to capture images of the patient's skin, and then send them via video stream (connected to a computer) to an urban dermatological specialist who would read the images, make a diagnosis, and send the rural health provider a treatment plan for the health problem.

Other applications include patient monitoring, which allows patents to stay at home while they convey personal information to their health professionals via telephone; use in prison systems to cut the costs of transporting prisoners to health clinics while reducing the dangers to civilian populations of prisoners on the move; and the delivery of health care to remote areas.

Over the past five years, significant changes in the telehealth industry have been tied to rapid technology advances and the convergence of the communications, media and computer industries. What has been even more dramatic is the exponentially expanding global reach of the Internet, which grew out of a community of U.S. developers to reach a world- wide global audience in just a few years. As consumers and businesses find more ways to use the Internet in their homes and businesses, the next generation Internet will enable these tasks to be accomplished faster, more securely and reliably than on our present system. Part of the anticipated next generation Internet, Internet2, is a joint venture by academia, the federal government and industry. This group is using a new high speed backbone network with a core sub-network consisting of a 2.4 Gbps, 13,000-mile research network to test Internet applications such as Internet Protocol (IP) multicasting, differentiated service levels and advanced security.[6] It will also allow researchers to test and resolve problems such as bandwidth constraints, quality and security issues.

The digital revolution is already upon us. Digitized data, voice, still images and motion-video can be mixed, matched, melded and sent over myriad types of conduits. Advances in digital and compression technology enable vast amounts of information to be stored onto smaller and smaller chips. Applications of this technology include the creation of digital medical libraries and medical databases, as well as the potential to widely adopt Electronic Medical Record Systems and Smart Cards that can hold medical information on a card the size of a credit card. Smart cards are already in use to a limited degree here in the U.S. and more widely overseas. Currently, however, there are no technical standards that can help to easily integrate telemedicine clinical data onto these systems and cards.

The use of wireless telemetry in hospital settings is already standard practice. Emergency Medical Services companies are or will be important users of telemetry and other wireless technology. Companies already use wireless telemetry or more advanced wireless technology such as wireless interactive video on emergency vehicles to communicate with emergency physicians. It enables a paramedic to confer with an emergency physician for an early assessment, well before the patient's arrival at the hospital. Telemedicine equipment can be as simple as a laptop computer with desktop video conferencing capabilities that provide simultaneous two-way video, two-way voice, vital signs, cardiac and other data to a trauma center. Wireless technology is also useful in an emergency care hospital because emergency physicians, consulting a hand-held wireless device, do not have to leave the patient's side while researching unfamiliar symptoms. Other wireless technology applications in telemedicine and telehealth will emerge as people adopt wireless applications in their every day lives. For example, the average consumer will be able to carry a mobile library of health information and diagnostics contained in a pocket-sized handheld wireless computer. With such a wireless palm computer, the practitioner can send patient medical information from the hand held device to another wireless device next door, around the world, or to a main data center in the hospital for storage.

CIVILIAN TELEMEDICINE

The private sector is an important player in furthering the development and application of telemedicine technologies. Telemedicine is also a world wide application not only limited to the United States. No single private sector strategy exists to advance this emerging technology. For example, manufacturers develop new products, utility companies build the telecommunications infrastructure, professional organizations develop health care standards, health providers deliver medical care, and special interest groups promote the use of new technologies. Each of these groups has its own interests and strategies for advancing telemedicine.

MAYO CLINIC

Telemedicine at the Mayo Clinic evolved to facilitate integration of group practices at three separate locations—Jacksonville, Florida; Scottsdale, Arizona; and Rochester, Minnesota. In 1986, the Mayo Foundation installed a satellite-based video system that enabled physicians, researchers, educators, and administrators to communicate with each other. When the Jacksonville and Scottsdale facilities were not fully staffed, they used specialists from Rochester via telemedicine for four or five consultations per week. However, with the addition of specialists at the Jacksonville and Scottsdale locations, the telemedicine system was increasingly used for education, research, and administrative purposes. According to Mayo in 1995, its telemedicine system was used for over 700 telemedicine consultations in echocardiology between Rochester and the two other sites.[7]

Mayo is also involved in a project supported by Rochester and NASA, to explore the combination of satellite communication and terrestrial services in an economic telemedicine model. The results from this project will help determine a strategic policy for telemedicine at the Mayo Clinic and provide knowledge about the use of asynchronous transfer mode technology (ATM) for local area and wide area networks.

ALLINA HEALTH SYSTEMS

Allina Health Systems is a managed care organization and insurer from Minneapolis, Minnesota. Along with an alliance of eight rural hospitals, Allina has operated a telemedicine network that links hospital emergency rooms since 1995. Allina believes that emergency medicine in rural areas is the best application of telemedicine currently available for its operation. As of 1996, Allina's telemedicine network had been used for about 130 medical consultations and about 450 emergency service consultations. Allina's network is a single-state system, which eliminates concerns about licensure requirements that plague many telemedicine efforts. The use of Allina's telemedicine network in urban areas is quite different than its use in rural areas. For example, in urban areas there is more extensive use of the system for administrative and educational purposes and virtually no use for consultative purposes.[8]

AT&T

AT&T's strategy for telemedicine development involves developing services for telecommunication applications, transactions, and networking and providing telecommunications and some training for computer-based medical systems. These efforts have accelerated since the creation of the National Information Infrastructure. The National Information Infrastructure is an ongoing effort to control and regulate the expanding telecommunication architecture in the United States. AT&T's involvement in telemedicine efforts is largely due to the company's perception, which was confirmed by clients, of a need for reliable and secure communication lines for health care.[9]

THE IOWA COMMUNICATIONS NETWORK

A typical example of a public network is Iowa's statewide fiber optic communications systems, the Iowa Communications Network (ICN). ICN was originally established to provide equal learning opportunities for all Iowa schools, regardless of size, remoteness, or resources. The availability of telecommunications technologies and the statewide fiber optic infrastructure provides many benefits to the state. Iowa has one of the largest elderly populations in the nation, yet only about 10 percent of Iowa hospitals provide geriatric health programs, Alzheimer's diagnosis units, or respite and hospice care. The leading cause of death for Iowa residents under the age of 40 is trauma. Yet only 12 percent of Iowa hospitals provide trauma care. Access to advance technology, allied health services, emergency trauma centers, and public health is limited in Iowa's rural communities. Rural residents often have to travel long distance to receive care beyond the primary level. With the aid of telemedicine, Iowa's population is better served.[10]

Rural healthcare providers are professionally and physically isolated from their colleagues and subspecialty consultations. This isolation results in inadequate access to information and services available in secondary and tertiary level institutions. Such conditions create a barrier to optimal patient care and to professional satisfaction. Another important application for telemedicine is distance learning and continuing education for community health providers who do not have access to the kind of information-sharing and continuing education opportunities that are often taken for granted in urban locations.

The building of a telecommunications infrastructure allows community health providers' local access to innovative and interactive continuing education opportunities with a minimum of time and travel. The College of Medicine at the University of Iowa is sponsoring a computer classroom which will be adjacent to the Telemedicine Resource Center. Creating health education programs in electronic format will have the added value of making them accessible to community practitioners through a telecommunications network.[11]

PENITENTIARIES

In September 1996, a telemedicine suite was opened at the US Penitentiary at Allenwood, Pennsylvania, with telecommunications linkages to the Department of Veterans Affairs Medical Center (VAMC) in Lexington, Kentucky. The telemedicine suit was designed to serve inmates at this prison and at the adjacent Federal Correctional Institution at Allenwood. Four months later, in January 1997, a second suite was opened at the US Penitentiary at Lewisburg, Pennsylvania. Telemedicine equipment was also installed during the closing days of 1996 in the Federal Bureau of Prisons' Federal Medical Center in Lexington, Kentucky.[12]

In this network, all four prisons served as remote sites, meaning that prisoners and healthcare providers there would initiate requests for services from the providers of telemedical specialist services at the hub site. VAMC was designated the major hub for this network, and planners secured agreements with VAMC's administrators to provide physicians in several specialties thought to be suited to telemedicine and the needs of the remote sites. In addition to serving as a remote site, the Federal Medical Center at Lexington was also designated a minor hub, as it was to provide telepsychiatry services to the other three remote prisons.

The principal objective of the demonstration was to test the feasibility of using a sophisticated array of telemedicine equipment for remote specialty consultations and develops data from which to project the impact of telemedicine on healthcare spending for a prison population.

The technology used in this demonstration is standard, commercially available equipment, and although a physician's skill is required to operate it, physician assistants can readily gain proficiency. A physician is not required at the remote location. Consequently, a single specialist can serve a number of remote locations, and each remote location has access to all the specialists in the network. Several results from this ongoing study are as follows: Fewer security risks for transfers and external consultations; shorter waiting times to see specialists, access to better quality specialists and to specialty care not previously available; fewer acts of inmate aggression or use of force by the guards due to improved mental health services; and fewer grievances about healthcare or mental healthcare.[13]

ARIZONA RURAL TELECOMMUNICATIONS NETWORK

The Arizona Rural Telecommunications Network connects specialists at the University of Arizona's hospital and elsewhere with smaller hospitals, medical centers and, most recently, prisons across the state of Arizona. The network is a private ATM network with IP-based store-and –forward applications such as teleradiology, in which a CT scan is sent as part of a multimedia e-mail message. It also runs real-time ATM video clinical sessions between physicians and patients.[14]

With the IP-based teleradiology application, a local physician sends patient CT scans, X-rays, digital photographs, and other information to a coordinator who refers the case to the appropriate specialist, typically at a big hospital such as the University of Arizona Health Sciences Center. The network uses LANE (LAN Emulation) to send IP applications, including a distributed image archive for teleradiology, over the ATM Wide Area Network. The emerging teleradiology archive not only would mean adding distributed storage technology, but also more bandwidth to run it.

Another bandwidth-heavy application on the horizon is an anesthesia simulator, which will be used by medical students and residents. The application, which uses interactive video over ATM, can be programmed to simulate a patient's heartbeat and respiration while he or she is under anesthesia to train students at remote locations. Consideration is being given for a microwave infrastructure in lieu of the DS-1 based ATM circuits.[15]

FINLAND

For the past 10 years general practitioners in Finland have been able to make electronic referrals to the Peijas Hospital in Helsinki. Many of these referrals can be dealt with by the hospital staff without the patient needing to attend the outpatient clinic, either by electronic messages or by arranging a teleconsultation by video link. A 20 month study found that 52% of the referrals from general practitioners were dealt with electronically. This was a much cheaper method of referral than the traditional method, as used by two control groups of general practitioners with similar patients. The direct costs of a visit to an outpatient clinic in internal medicine were seven times greater per patient than those of an electronic consultation.[16]

U.S. DEPARTMENT OF AGRICULTURE

A live video link was established between U.S. Department of Agriculture headquarters and a rural health clinic in Haxtun, Colorado, a small farming community about 120 miles northeast of Denver. The High Plains Rural Health Network took advantage of this link. The High Plains Rural Health Network began 10 years ago, and now provides vital services and economies of scale to 19 rural healthcare facilities in western Kansas, eastern Colorado, western Nebraska and southern Wyoming. These healthcare facilities in towns ranging in populations from a few hundred people to as many as 10,000 are connected via telecommunications to two urban hospitals. In addition to providing direct healthcare services for patients, the network helps local clinics with recruitment and retention of physicians and nurses, insurance claims, collections and purchasing. Professional healthcare staffs, local paramedics and others in the healthcare field routinely use the network for distance learning in required continuing education seminars.[17]

NASA

NASA in conjunction with Stanford University Medical Center is developing a virtual environment workbench to plan complex crainofacial reconstructive surgery. The team is designing grid generation methods and computer software to combine laser scans with computer tomography and magnetic resonance imaging to make three-dimensional constructions of the face and head.[18]

The surgeon plans reconstruction in this virtual environment by exposing the skull beneath the face to remove bone, cut it into appropriate sections and replace them. Soft tissues are replaced computationally, and facial features are remolded automatically to the new skull. Once the surgeon is satisfied, he or she uses the workbench to prepare for actual surgery.

The workbench also could be used to train crainofacial surgeons. More than 50 steps with specific tools must be followed in exact sequence. Trainees would sit before a computer screen and practice these steps before ever touching a patient.

The Virtual Reality Applications Program is developing, evaluating and using an inexpensive virtual reality human cadaver software application for classroom anatomy instruction. The software will run on a Pentium-based personal computer. The detailed model will include subdivided organs, texture mapping and three-dimensional sound for the major organs. This immersive learning environment is expected to afford quicker recognition, orientations and retention in human anatomic instruction. This project could lead to other virtual reality science training applications.[19]

The Jet Propulsion Laboratory and the Los Angeles County Center for the Vulnerable Child developed a Web-based system that enables fast turnaround on child abuse cases. The Virtual Center for the Vulnerable Child enables Internet-connected schools to use digital cameras to report suspected child abuse cases to a group of child abuse experts. Specially equipped remote clinics use telemedicine equipment, such as a videoconferencing system combined with a special dermatology scope; to perform exams in real time should further inspection be required.[20]

GEORGIA

The State of Georgia has the first statewide telemedicine network in the country. The system has 32 sites, with another 22 planned. Each site is fully able to communicate with any other site. The system extends the reach of medical services, particularly specialty services to otherwise underserved areas. The single most common use of the network is for psychiatric consultation. Two thirds of Georgia counties have no psychiatrist and 90% have no child psychiatrist. Half of all the psychiatric video appointments on the network are the first visit the patient has had with a psychiatrist. Overall, 87% of the network's use is for scheduled clinics, where the patients come in to their local clinic and are seen by a specialist sitting in his own clinic miles away. The program saves an average of $50 per patient, compared with what it would cost to have a face to face appointment. In the 8 years that the program has been up and running, no patient who has had a telemedicine session has refused a second one.[21]

INDIA

The Apollo Hospitals a group of hospitals located in the Indian cities of Chennai, Hyderabad and Delhi, recently opened a Telemedicine Center at their Apollo Hospital Information Center. The city center will cater to patients of the Eastern and North Eastern states. These patients will no longer have to physically travel down to hospitals.

A patient wanting advice from an Apollo doctor can first contact the team of doctors present at the Center. After checking the case history and prescriptions of the patient, the team then co-ordinates with the doctor concerned at the Apollo Hospital. The patient's case history is sent to the doctor for his review. The doctor then gives a suitable date when he could be present for teleconferencing with the patient. The whole process is aided with the help of a web camera and a computer.

The patient and the doctor can see each other on the computer screen while talking to each other. While teleconferencing, the doctor will also advise the patient of a date for an operation if needed.[22]

CANADA

Emergency physicians and trauma surgeons at Vancouver General Hospital and Cranbrook Regional Hospital have demonstrated a unique and innovative clinical research project called the ER/Trauma/CME Telemedicine Project, a component of British Columbia Telehealth. This life-saving program provides real- time and on-demand support from the staff at the hospitals to emergency, trauma and critical care patients in rural or remote areas of the province. Medical expertise once only available at the major hospitals is now accessible to rural health professionals by the latest videoconferencing technology. It allows physicians at different hospitals to share as much information as possible including lab tests, X-rays, photos and eye exams.[23]

Activated on February 4, 2002, Telemedicine services have already been used 14 times by physicians and patients. In one case, an emergency physician at the hospital provided critical advice for a physician treating a patient with a complex and life-threatening cardiac condition, at one stage the patient was in full cardiac arrest. Without effective and appropriate care from both physicians, the patient would have died within minutes.[24]

AIRLINES

Virgin Atlantic Airways is about to install throughout its fleet of aircraft remote diagnostic systems that will allow physicians on the ground to remotely monitor the vital signs of stricken passengers.[25] The doctors will then be able to communicate with flight personnel on how to treat patients. The Tempus 2000, a remote monitoring device, will automatically relay a passenger's vital signs to emergency room physicians at a facility operated by MedAire Inc., a Phoenix company that has provided voice telemedicine services to airlines for 16 years.[26]

The Tempus 2000 sends real-time electrocardiogram information, temperature, blood pressure information and other vitals signs, including blood oxygen levels and respiration rates to computers at MedAire's MedLink facility at Good Samaritan Hospital in Phoenix using a built-in modem connected to a seat-back satellite phone.[27]

The satellite connection operates at 2.4K bit/sec. New compression protocols allow for the transmission of a still video picture in only 30 seconds.[28]

The Tempus 2000 features graphical help screens that guide flight personnel through every step of the setup process.

If a doctor determines that the medical condition of an onboard patient necessitates an emergency landing, the company's communications specialists can tap into a proprietary SQL database of 5,000 hospitals worldwide correlated with an airport database to determine the closest airport with the best medical facilities to treat the passenger.[29]

ARMY APPLICATIONS

A careful analysis of history illustrates that new technologies can have a profound impact on military operations. Gunpowder, machine guns, tanks and precision-guided munitions redefined the art and science of war in their eras. Military scholars refer to these technology-driven turning points as revolutions in military affairs (RMAs). RMAs force military leaders to reexamine their strategic framework and challenge their long-accepted doctrine, training, organizational structure and tactics in light of new operational realities.[30]

The surge of new information technologies into contemporary military organizations signals the advent of another historic RMA. The Army is being forced to commit increasing levels of managerial attention on how it will integrate computers, telecommunications and advance third wave technologies into mission-critical work processes. These new technologies will provide the Army of the 21st century with the ability to coordinate very complex, time-sensitive, high-tempo operations across the spectrum of combat and peacetime operations.[31]

While the military is in the midst of an information-driven RMA, the nation's healthcare delivery systems are simultaneously experiencing a historic revolution of another sort. In response to tighter restrictions on revenue growth, the decreasing ability of providers to raise prices and political pressure to find savings in federal healthcare accounts, healthcare providers are being forced to develop new strategic approaches for the future. In essence, health care is now faced with its own transition into the post-industrial Information Age.[32]

As a result, both civilian and military medical organizations are rapidly evolving into vertically and horizontally integrated managed care systems. These managed care networks exhibit an unconcealed rush to cut costs, to deliver health care services in new, more efficient ways and to open new markets and geographical areas to high-quality healthcare.[33]

In the Military Health Services System these pressures have led to the three-year effort to configure peacetime healthcare into a military managed care system called TRICARE. In 1995, these changes in military strategy and health care delivery led Headquarters, Department of the Army to approve the Mission Needs Statement for Medical Communications for Combat Casualty Care.

As Recognized in U.S. Army Medical Command's Task Force Mercury report, both TRICARE and Medical Communications for Combat Casualty Care exemplify what is at the heart of this revolution in military medical affairs, that the lifeblood of these managed care systems is evolving clinical information systems that can perform multimedia data acquisition, information processing and distribution to enable better coordinated health care, in lower cost settings unconstrained by geographical restrictions.[34]

The technologies that enable coordinated care between separated sites are what we generally consider telemedicine. The strategic intent of military telemedicine is to ultimately integrate advanced diagnostics, therapeutic devices, computerized patient records, interactive medical knowledgebase and high-bandwidth telecommunications into unified, clinically powerful managed care systems that extend the continuum of care from the frontline medic to the continental United States-based regional medical center. Because of these simultaneous RMAs in military and medical strategy, it is clear why the development of telemedicine, and more broadly all forms of medical informatics, has emerged as top priorities of the Army Medical Department.[35]

Current Department of Defense investment in telemedicine is substantial, over 300 million dollars directed at 192 projects during the years 1993-1998. Current DOD Telemedicine objectives are as follows: keep active duty forces on the Job; enhance and measure health of the force; reduce forward deployed medical footprint; modify military health system staffing model to reduce size and skill mix for support of military operations; and to increase efficiency of military health system.[36]

The Telemedicine and Advanced Technology Research Center (TATRC), a subordinate element of the United States Army Medical Research and Material Command, is charged with managing core and congressionally mandated advanced technology projects through improvements in the following areas: Knowledge Engineering, Combat Trauma Training Systems, Distance Learning, Computer Aided Instruction, Medical Imaging, Medical Data Fusion and Distribution, Image Guided Therapies, Minimally Invasive Therapies, Advanced Diagnostic and Therapeutic Systems, Wireless Medical Systems, Teleconsultation Systems, Robotics, Force Feedback-Virtual Reality, and Physiological Sensors.[37] To support its R&D efforts, TATRC has numerous partnerships with other Federal, academic, and commercial organizations. Additionally, TATRC provides operational support as directed, aggressively prototypes and demonstrates new technologies, and conducts market surveillance with a focus on leveraging emerging technologies in healthcare. Currently numerous programs are in finial stages of development and are showing promise.[38]

URETEROSCOPIC ENDOSCOPIC SURGICAL SIMULATOR

Although the military and airline industry have used computer-based simulators for many years, difficult technical challenges have limited the use of virtual reality in medicine. To address this, TATRC sponsored research that developed the technology to realistically interact with computer environments that represent accurate behaviors of tissues and organs. Invasive procedures require long recovery times, reducing readiness for our forces and increasing the costs associated with longer recoveries. Minimally invasive surgery, for which clear benefits can be demonstrated through shortened hospital stays and reduced patient traumas, has presented numerous challenges for the healthcare system.[39]

The prototype ureteroscopic simulator integrates technologies that push the boundaries in computer-base real time simulation. Technologies include computer models that represent the physics of collisions and resulting deformations during interaction of various medical devices as well as real- time physiologic modeling of tissue trauma.[40]

PERSONAL INFORMATION CARRIER

Numerous attempts have been made over the last decade to develop a device that can be used to store data electronically about the person. These devices have been generically termed personal information carriers. Such a device could be valuable for holding personnel, finance and medical data and could aid in streamlining processing of individuals for issuing equipment and supplies, for access to facilities or restricted areas, and as a component of an electronic medical record. The Personal Information Carrier currently under development and testing is a small, portable, large-capacity storage device that contains demographic and medical information pertaining to the service member who is wearing or carries the device.[41]

The Personal Information Carrier enables the capture and delivery of a wide array of data types including images, sound, movies, objects, databases, or hundreds of pages of text.

Using current flash memory and smart card technologies, the Personal Information Carrier will facilitate the creation of the multimedia electronic medical record for military healthcare in both peacetime and deployed environments by replacing existing paper records, film images, and analog audio/video recordings.

MEDIC-CAM

The Medic-Cam is an integrated wireless lightweight system which provides quality video, audio, and data communications between remotely located field personnel, such as medics, and highly-trained specialists.

The Medic-Cam is the front end of a video teleconferencing network. Medics have a wide-band live video microwave link to a transportable command station. The medics have a 2km line of sight range to the station. The command station provides computer power and satellite or terrestrial radio interface. A doctor or physician's assistant may occupy the vehicle and mentor the medics or pass the conference on to the specialists.[42]

SPECIAL FORCES MEDICAL DIAGNOSTIC SYSTEM (SFMDS)

The mission and function of the SFMDS is to provide electronic information management tool for Special Operational Forces medical personnel. The project integrates the major functions of a medical reference library, diagnostic and treatment decision aids, medical sustainment training, and medical mission planning, into a single portable computer-based device with internet access and update capabilities. The special forces medic's training transcends the combat medic's training in the areas surgery, anesthesia, dentistry, veterinary medicine, laboratory, pathology, pharmacology, radiology, psychiatry, obstetrics, gynecology, pediatrics, tropical, preventive and internal medicine, in austere environments that do no have sophisticated medical support.[43]

The SFMDS records the essential elements of medical decision support rules to provide immediate decision feedback as well as modules containing interactive simulations to support readiness sustainment. Continuing development efforts may include incorporating teleconsultation, medical reconnaissance, personal information carrier interface, medical speech recognition, language translation and chemical/biological threat modules.

WARFIGHTER INFORMATION NETWORK

In November 1999, the U.S. Army Medical Research and Material Command's Telemedicine and Advanced Technology Research Center demonstrated the results of its three-year collaboration with Fort Gordon Signal Battle Command Battle Lab and the South East Regional Medical Command Center to integrate telemedicine and Satellite communications capabilities into the Army Warfighter Information Network mobile communications switch, as a platform for providing multi-user broadband medical command and control communications and telemedicine connectivity.[44]

The Warfighter Information Network switch provides communications from forward deployed areas and joint task force headquarters locations rearward to the Theater and National Military Command Headquarters and Military Health System Medical Centers worldwide. The switch is an asynchronous transfer mode switch capable of receiving and transmitting voice, data and video simultaneously from multiple deployed sites using either military or commercial radio, wired, wireless or satellite communications. It can also be equipped with a local cellular or other wireless telephone switch to provide both local and long distance telephone service.

Specific telemedicine applications tested at this point include the following: Special Forces Medical Diagnostic System; teledermatology; teledendistry; Ask-a-Doc via the Walter Reed Army Medical Center Composite Health Care System; the Joint Medical Asset Repository system; video-teleconferencing; wired and wireless phones, pagers; and the Army Medical Command Special Augmentation Response Team Medical Command and Control, Communications and Telemedicine terminal.

SPECIAL MEDICAL AUGMENTATION RESONSE TEAMS

The US Army Surgeon General, in consultation with the Chief of Staff of the Army, directed the US Army Medical Research and Material Command's Telemedicine and Advance Technology Research Center in March of 1998 to develop and support a telemedicine equipment set for Medical Command, Control, Communications and Telemedicine (SMART-MC3T).[45]

The teams provide short duration, augmentation to regional domestic, federal and defense agencies responding to disaster, civil-military cooperative action, humanitarian and emergency incidents throughout or outside the United States. Their main objective is to provide local authorities with medical situational awareness and telemedicine services.

SMART is equipped with a combination of commercial off the shelf technologies. The components consist of the following items: an International Maritime Satellite terminal providing

64kbs of bandwidth, dual band cellular phones, digital dual band radios, interactive video-conferencing and computer capability, a self contained power supply, and an uninterrupted power source. This combination of technologies allows self-sufficient store and forward capability with Internet and telephony coverage anywhere in the world. Current upgrades to the system will reduce the size and pallet requirements from 3 hard clam shell cases and 1 cargo pallet to 1 hard clam shell carry-on capability.[46]

IMPACT

From the medical perspective, advances in information and telecommunication technologies can be exploited to military advantage through their combined application with advanced biomedical technologies. Telemedicine is not however, the panacea for either military health care or combat medical support. Wilder claims by its advocates have suggested that helmet cameras and two-way communications linked back to a field hospital from first responders would substantially reduce combat fatalities. In reality only 5 percent of battlefield mortalities are salvageable, in general those from bleeding and chest wound categories. The critical issue is to identify and deploy technologies that can help rather than hinder combat medics. There are currently three ways in which telemedicine can have a positive impact on current DOD medical practices.

Prior to deployment, these new capabilities will improve joint readiness by providing medical forces with access to intelligent computer-aided medical instruction, collaborative mission rehearsal, and realistic medical and surgical simulations. These capabilities will greatly enhance the ability of military health care providers to attain combat trauma skill proficiency, maintain currency of medical skills, and develop expertise in joint unit level operations through iterative rehearsal of simulated task force missions.

During combat, telemedicine will provide battlespace awareness of the health status of individual warfighters and units, allowing line and medical commanders to proactively monitor, measure, predict, and manage the health of the force using real-time physiological sensors, large-scale distributed medical databases, computerized patient records, and medical situational awareness. Real-time knowledge of the physiological status of U.S. forces will add a new dimension to situational awareness, enabling commanders to predict individual warfighter and unit effectiveness, optimize utilization of forces, minimize casualties, and rapidly identify casualties when they occur.

Telemedicine technologies are also critical enablers for battlefield health care delivery. They are essential to keep pace with and deliver quality care to highly mobile dispersed forces.

When illness and combat trauma strike, telemedicine will enable commanders to improve the effective employment of medical forces. It will provide new capabilities for predictive diagnostics, digital image acquisition devices, 3D image processing, clinically focused teleconsulation systems, and better informed, less invasive surgical treatment that improve clinical outcomes. Telemedicine capabilities will also allow casualties to be managed across the echelons of care, and provide the advanced diagnostic and resuscitative capabilities, artificial intelligence-based prognostics, and enroute monitoring and interventions that enable more critically injured patients to be evacuated before they are fully stabilized.

IMPLICATIONS

COSTS. Telemedicine comes with significant costs. Consider that medics must be equipped with video and information conferencing devices and that every field hospital would have to be equipped with some form of server and input/output technology to assist the first providers and the cost becomes staggering. With current information technologies advancing every 18 months, upgrading equipment will also be financially challenging. Significant additional expenditures will be needed to implement telemedicine initiatives. But where will the funds come from? With the current emphasis on the war on terrorism, there will continue to be a situation where there are too many projects and not enough dollars to go around. Pressure has already been felt to reduce the medical force structure and facilities. Access to healthcare for non-active duty has been increasingly limited in military medical facilities and TRICARE is bearing more payments to civilian contractors. Telemedicine does show some promise at reducing health care costs. For example, video consultations can shorten diagnostic time, reduce treatment time, and decrease hospital stays. Telemedicine can also reduce evacuation or travel costs incurred when patients and specialists have to travel for consultations. These potential savings may be offset by infrastructure costs and increased use emphasizing the requirement for leaders to effectively deal with future healthcare budget constraints. No doubt, the costs of telemedicine initiatives will be one of the driving forces for military medicine to change as we enter the new century.

PERSONNEL. Military medicine will need the best and brightest to become healthcare providers in the next century. Much more will be required of the medic in the future to be able to take advantage of the telemedicine initiatives. With the military already experiencing a shortage of doctors, nurses, and other health professionals, how will it retain and attract quality recruits who have additional skills that are marketable outside the military? Additional pay benefits and quality of life inducements have helped, but these are not the solution. As with many other skills, the military is at the cutting edge in telemedicine. By continuing research, and by exploiting the experience that in many cases can only be attainted in the military medical community, recruits will continue to flow into the system. Retention of high quality medical professionals will continue to be a significant issue as military medicine modernizes.

TRAINING. The inclusion of telemedicine technologies into the combat health support system will have a significant impact on training within the military medical system. It will prolong both initial and sustainment training for both officers and enlisted. The combat medic will require additional competencies to maximize the impact of telemedicine. As with many other fields impacted by the information technology wave, medical personnel will need to be retrained on a multitude of skills. This requirement will significantly extend medical training and involve a greater commitment of time to maintain these additional competencies through sustainment training. There is little doubt that additional training will require greater personnel and monetary resources. Paying for these resources with smaller healthcare budgets will be another challenge.

CONCLUSION

The dawn of the new millennium is a time of great opportunity linked with the requirement to make decisions that will affect us in the coming century. Dr. Stephen C. Joseph, assistant secretary of defense for health affairs, at a speech to the National Security Industrial Association Medical Technology Education Conference said,

> "These technologies, like telemedicine, are agents of change. They carry significant implications for how medicine will be practiced, yet medicine remains a curative art firmly based in science. As an agent of change, telemedicine carries significant implications for how military medicine will operate, yet the mission responsibilities of military medicine to provide care wherever and whenever needed remain the same. The important point here is that telemedicine is a tool to be used to improve the delivery of health care."[47]

The Army's Telemedicine program is a promising information-age capability. It provides round the clock medical consultation services. Current technology allows the transference of diagnostic quality images from deployed remote facilities to medical centers. It also allows video teleconsulation with diagnostic scopes, high speed file transfer, telephone and facsimile support. Ongoing integration efforts are focused on adding increased speed, larger transfer capability, and increases virtual reality programs. It is already in use throughout the world and has already been proven during deployments to Macedonia, Croatia, Haiti, Somalia, Haiti, Kuwait, and Afghanistan.[48]

As with any revolution, the speed of change and transformation can be dizzying at times. Confusion and dead-end research projects must be expected and seen as the natural result of integrating new technology with emerging doctrine. However, the benefits and possibilities of the current telemedicine suites and those of the future make the continued research and funding of telemedicine an imperative for the Army of the 21st Century.

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